FCS EVALUATION CRITERIA FOR TECHNOLOGY ASSESSMENT

Integrated CNS Technologies Conference & Workshop
Space Communications Program, NASA Glenn Research Center
1 - 3 May 2006

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Briefing Introduction & Outline

- This briefing describes the work supporting NASA, the FAA and EUROCONTROL to develop technology evaluation criteria for evaluation of new technologies for mobile aeronautical communications as part of the FCS

- Briefing Outline
  - Background
  - Evaluation Criteria Derivation/Suggested Evaluation Criteria
  - Using the Evaluation Criteria

Background

- ICAO ANC/11 noted:
  - Aeronautical communication infrastructure has to evolve
  - Various proposals to address this problem have been offered; none has achieved global endorsement
  - There are universally recognized benefits of harmonization and global interoperability
- Consequently, ANC/11 recommended:
  - Adopt an evolutionary approach for global interoperability
  - Investigate new terrestrial and satellite-based technologies
  - Undertake new standardization work only when system meets ATM requirements, is technically proven, consistent with the requirements for safety, cost beneficial and promotes global harmonization
- FAA and Eurocontrol embarked on a bi-lateral study (FCS) with the support of NASA; study is to provide input to the ICAO Aeronautical Communications Panel (ACP)
  - FCS goals and process are outlined in Action Plan 17 (AP-17)

Background – Future Communications Study

– FAA/Eurocontrol 3 year joint study*
– Objectives:

- Identification of requirements and operating concepts
- Investigation into new mobile communication technologies
- Investigation of a flexible avionics architecture
  – Development of a Future Communications Roadmap
- Creation of industry buy-in
- Improvements to maximise utilisation of current spectrum

* *Federal Aviation Administration/EUROCONTROL , Cooperative Research and Development Action Plan 17: Future Communications Study (AP 17-04)*

Background – Technology Investigations

- Technology pre-screening was conducted by Eurocontrol and the FAA/NASA team from April through December 2004
- Technology pre-screening process, evaluation criteria, and results have been briefed to ICAO ACP WGC and WGW
  - WGW endorsed the pre-screening process
  - Desired the authors to show traceability between the evaluation criteria and the "Communications Operating Concept and Requirements (COCR) for the Future Radio System"
  - Desired the authors to separate voice and data requirements, focus on a data-only solution (keeping in mind that a future system would augment existing systems) and repeat the pre-screening process
- This work provides the results of a structured analysis of the COCR
  - Set of evaluation criteria focused on data only requirements that are strictly traceable to the COCR and other consensus ICAO documents
- The pre-screening process will be repeated using these suggested evaluation criteria

Evaluation Criteria Derivation

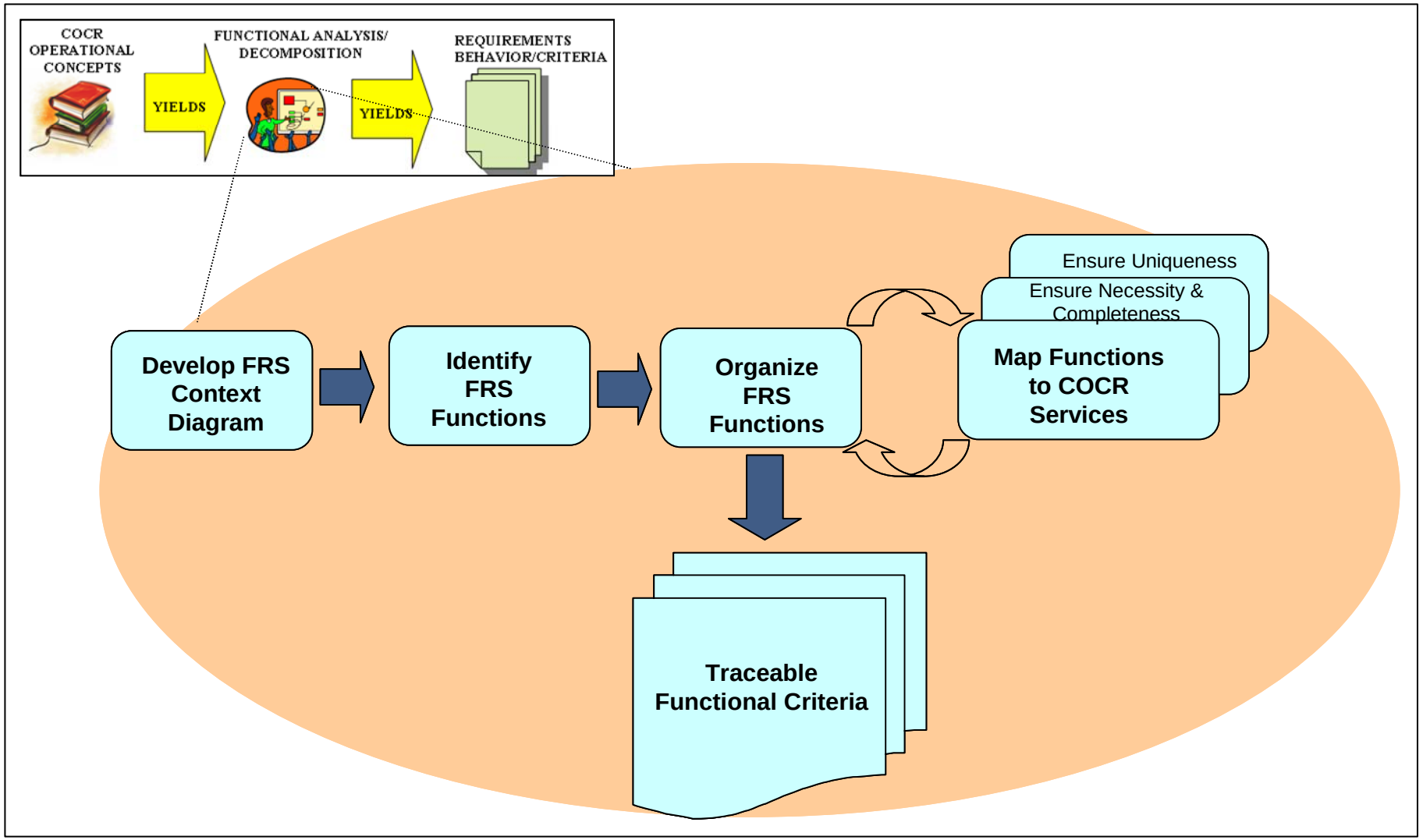
- Analysis of existing evaluation criteria indicated two types of criteria had been applied in the past to accommodate technical and strategic objectives of a future communication system
  - Technical Criteria – Address the required performance and functions of the future radio system. These criteria are derived from user requirements, as documented in the COCR
  - Institutional Criteria – These criteria address the elements of a technology that make it a viable solution, and are derived from consensus ICAO documents
    - Principle source of these requirements are the ICAO ANC-11 recommendations that precipitated the FCS

Technical Criteria Derivation

- Inspection of COCR led to further distinction in defining Technical-Evaluation Criteria:
  - Technical-Evaluation Criteria *(Functional)*
  - Technical-Evaluation Criteria *(Performance)*

COCR Section	Criteria	Comment
1. Introduction	--	--
2. Operational Services	**Functional Requirements**	Ability of the FRS to enable defined services
3. Operational Environment for Communication	**Functional Requirements**	Ability of the FRS to support the described operational environment
4. Safety and Security Requirements	Security	Assess provision of authentication, data integrity check & resistance to jamming (Note: safety requirements are specific to operational services and used to derive communication system & procedural requirements)
5. Operational Performance Requirements	QoS Priority Provisions (**Performance**); Latency (**Performance**)	Assess provision of classes of service and achievement of defined RCP (integrity/availability not utilized – discussion to follow)
6. Communication Loading Analysis	Number of Users (**Capacity**); Data Rate (**Capacity**)	Ability to service the number of users identified and accommodate the defined communication load (data rate)
7. Relationship of the Results to a Real World Environment	--	--
8. Conclusions	--	--

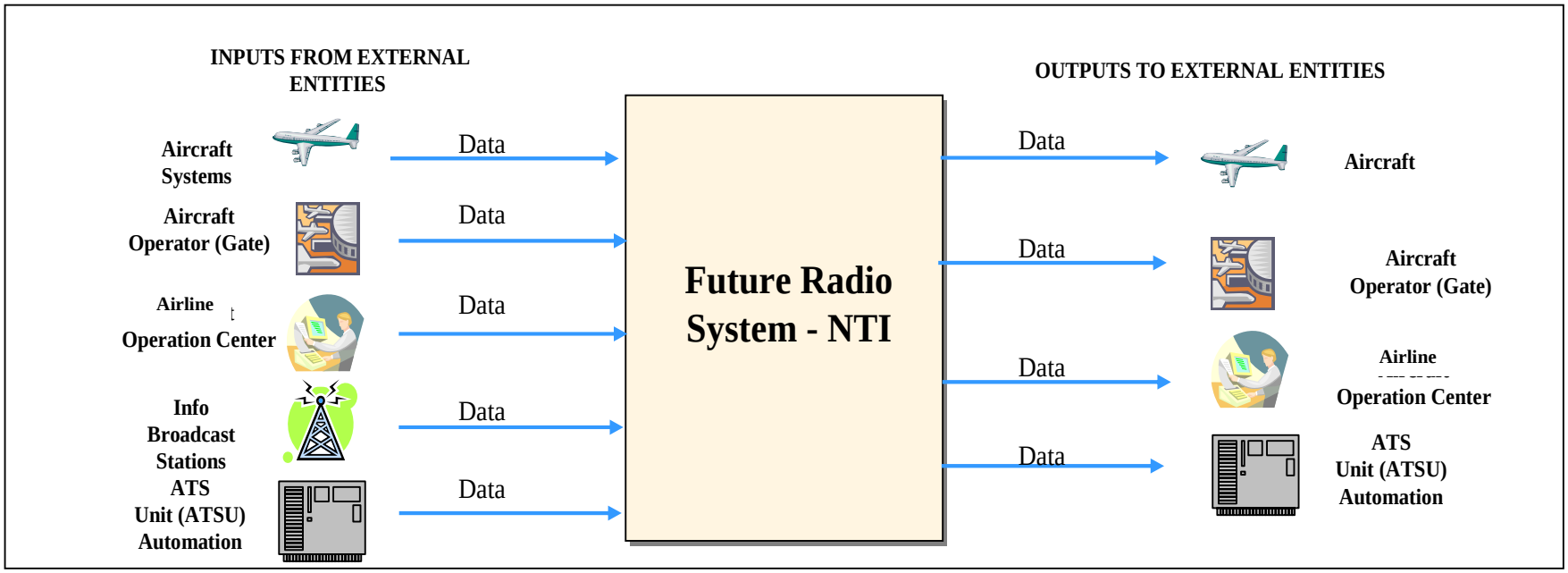
Technical Criteria Derivation (2)



Technical Criteria Derivation – Develop Context Diagram

- The operational context diagram is used to show:
  - Actors identified in the operational concepts
  - Interfaces between the actors and the system
  - Required information flow across these interfaces
- Both actors and interfaces for the FRS were identified by parsing the COCR
  - Consideration given to stakeholder direction during context diagram development

Technical Criteria Derivation – Develop Context Diagram (2)



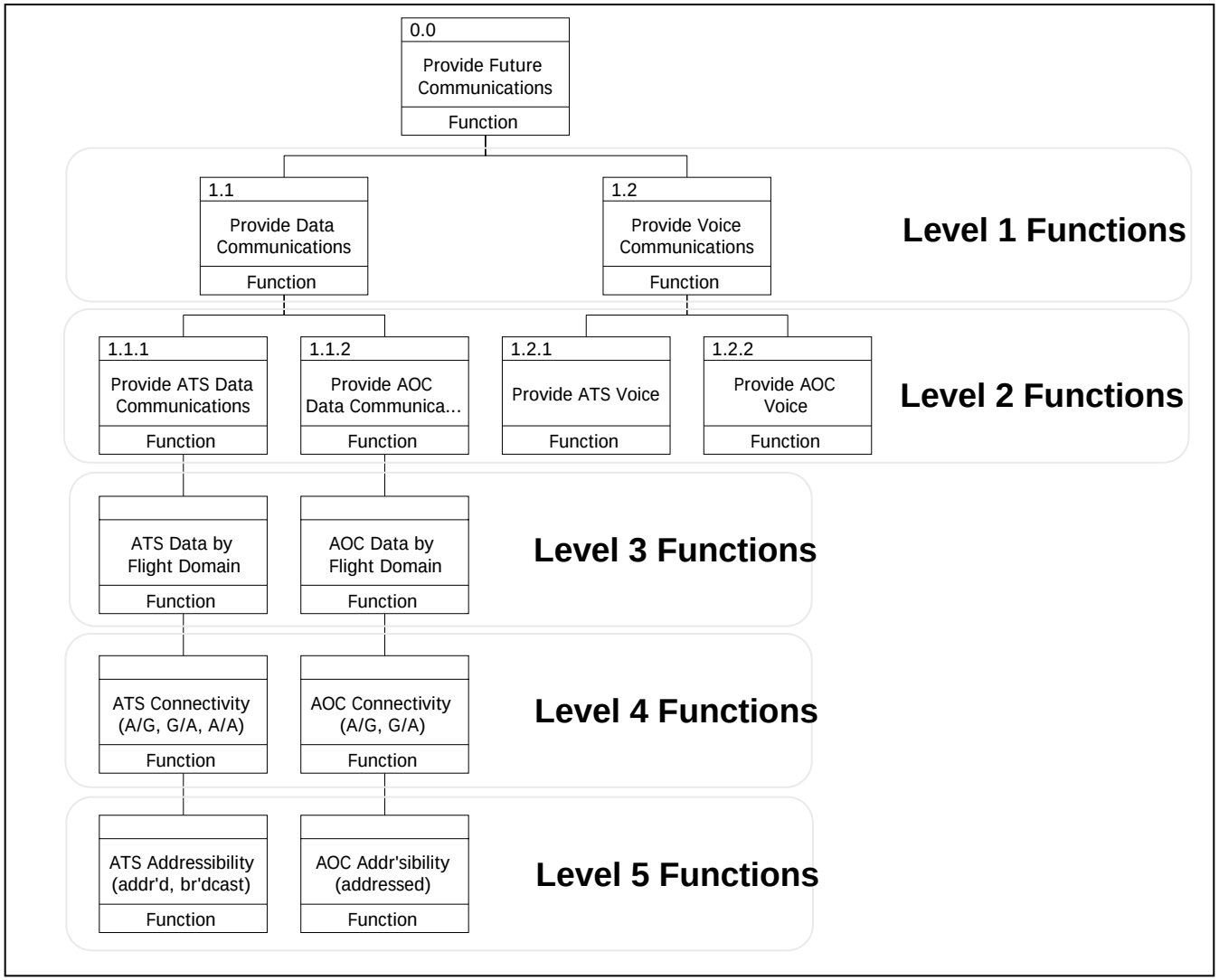
Technical Criteria Derivation – Develop Context Diagram (3)

- The name *Future Radio System – New Technology Implementation (FRS-NTI)* is used in the context diagram to reflect assumptions that were applied during the development of the context diagram

- Assumptions include:
  - Voice Communications are allocated to 25kHz DSB-AM and 8.33 kHz DSB-AM systems per ATMAC recommendations and ICAO ACP WGW direction (not included in context of FRS-NTI)
  - Surveillance/ADS-B interfaces are allocated to legacy UAT and Mode S systems (and not included in this context of the FRS-NTI)
  - Navigation interfaces are accommodated by legacy/planned navigation systems

Technical Criteria Derivation – Identify/Organize Functions

- Functional hierarchy derived from structured analysis of COCR



Technical Criteria Derivation – Map Functions to Services

- Exploring permutations of the functional hierarchy components and mapping functions to COCR services yields FRS functions

- Mapping also captures traceability of functions to COCR
  - Forward traceability (ensure each COCR services is supported by at least one communication function)
  - Reverse traceability (ensure all defined functions are used to support at least one COCR service, i.e. they are needed)

Technical Criteria Derivation – Map Functions to Services (2)

- Excerpts from function-to-COCR traceability table

	COCR ATM Service	ATS A/G & G/A Addressed Airport	ATS A/G & G/A Addressed TMA	ATS A/G & G/A Addressed Oceanic/Remote	ATS A/G & G/A Addressed Polar	ATS A/G & G/A Addressed Autonomous	ATS G/A Broadcast Airport	AOC Airport	AOC TMA	AOC En Route
ATS	**ATC** - Clearance (ACL)	X	X	X	X					
ATS	**ATC** - Mic Check (AMC)	X	X	X	X		X			
ATS	**ATC** - DL Taxi Clearance (D-TAXI)	X	X							
ATS	**ATC** - Departure Clearance (DCL)	X								
ATS	**ATC** - Downstream Clearance (DCL)			X	X					
ATS	**ATC** - Pilot Preferences Downlink (PPD)	X	X	X	X					
ATS	**ATC** - Dynamic Route Availability (DYNAV)			X	X					
ATS	**ATC** - Arrival Manager Info (ARMAND)									
ATS	**Auto Downlink** - FP Consist. (FLIPCY)	X	X	X	X					
ATS	**Auto Downlink** - FP Intent (FLIPINT)	X	X	X	X					
ATS	**Auto Downlink** - System Access Param (SAP)		X							
ATS	**Flight Info** - Operational Terminal Info (D-OTIS)	X	X				X			
AOC	Out Off On In (OOOI)							X		
AOC	NOTAM Request/NOTAMs							X		X
AOC	Free Text									X
AOC	Wx Request/Wx Report							X		X
AOC	Position Report								X	X
AOC	Flight Status							X	X	X
AOC	Fuel Status									X

Suggested Technical Criteria

- Technical-evaluation criteria (functional) are inferred directly from the functional analysis and the suggested criteria are shown in the table

Suggested Criteria Level 1	Suggested Criteria Level 2	Applicable Domains
Meets ATS Data Link Needs	A/G & G/A Addressed	APT, TMA, ENR, ORP, AOA
	Ground Originated Broadcast	APT, TMA, ENR, ORP, AOA
	A/A Addressed	APT, TMA, AOA
	Air-Originated Broadcast	APT, TMA, ENR, ORP, AOA
Meets AOC Data Link Needs	A/G & G/A Addressed	APT, TMA, ENR, ORP

Suggested Technical Criteria (2)

- Technical-evaluation criteria (performance) come directly from inspection of the COCR and include:
  - Capacity Criteria:
    - Data Rate
    - Number of Users
  - Performance Criteria:
    - QoS Priority Capability
    - Latency

Suggested Technical Criteria - Traceability

- Traceability of functional technical criteria shown in matrices that map functions to COCR services (shown previously)
- Traceability of performance criteria to COCR material shown here

Criteria	References
Data Rate	Table 6-19 A/G Capacity Requirements – Phase 1; Table 6-20 A/G Capacity Requirements – Phase 2; Table 6-21 A/G Capacity Requirements excluding A-EXEC service – Phase 2; Table 6-22 A/G Capacity Requirements for each Aircraft using a Separate 'Channel' – Phase 1; Table 6-23 A/G Capacity Requirements for each Aircraft using a Separate 'Channel' – Phase 2; Table 6-24 A/G Capacity Requirements for each Aircraft using a Separate 'Channel' excluding the A-EXEC service – Phase 2
Number of Users	Table 6-1 PIAC Projections
QoS Priority	Table 5-9 Data COS (Type DG – A/G Addressed); Table 5-10 Data COS (Type DA – A/A Addressed); Table 5-11 Data COS (Type DB – A/A Broadcast); Table 5-12 COS Assignments (Network Management) – Phase 1 & 2 Table 5-13 COS Assignments (ATS) – Phase 1 & 2; Table 5-14 COS Assignments (AOC) – Phase 1 & 2
Latency	Table 5-6 FRS Allocated Data Performance (ATS) - Phase 1; Table 5-7 FRS Allocated Data Performance (ATS) - Phase 2; Table 5-8 FRS Allocated Data Performance (AOC) - Phase 1 & 2;

Institutional Criteria Derivation

- The Institutional-Evaluation Criteria were essentially derived from Recommendation 7/5 from the 11th Air Navigation Conference, which reads:

  – *"Continue to monitor emerging communication systems technologies but undertake standardization work only when the systems meet all of the following conditions:*

    1) meet current and emerging ICAO ATM requirements

    2) be technically proven and offer proven operational benefits

    3) be consistent with the requirements for safety

    4) be cost-beneficial

    5) be consistent with the global plan for CNS/ATM Systems"

Institutional Criteria Derivation (2)

- To further consider Recommendation 7/5 part 5, the global plan for CNS/ATM systems was reviewed
  - The global plan indicates in Section 5.14 [Future Communication] Trends,
    - " The most important question to be asked when considering a new system is whether it meets existing or emerging operational and user requirements. Other factors to be considered are standardization, certification, harmonious deployment by various users, and cost benefit considerations"
  - The Global Plan also includes a Statement of ICAO Policy on CNS/ATM Systems Implementation and Operation (Appendix A to Chapter 2)
    - Statement outlines requirements for implementation and operation of future CNS/ATM systems including requirement for flexible transition and ability to provide continuous service with specified integrity and with required priority, security and interference protection.

Suggested Institutional Criteria

	Evaluation Criterion	Description (& sub-items)	Traceability
1	Technical Readiness Level	Provides an indication of the technical maturity of the proposed technology (Technical Readiness Level)	11th ICAO Air Navigation Conference (Sept/Oct 2003) Recommendation 7/5 – Number 2
2	Standardization Status	Indicates the relevance and maturity of a proposed technologies standardization status.	Global Air Navigation Plan for CNS/ATM Systems – ICAO Doc 9750 (5.14) 11th ICAO Air Navigation Conference (Sept/Oct 2003) Recommendation 7/5 – Number 3
3	Certifiability	Provides a relative measure of the candidate complexity.	Global Air Navigation Plan for CNS/ATM Systems – ICAO Doc 9750 (5.14) 11th ICAO Air Navigation Conference (Sept/Oct 2003) Recommendation 7/5 – Number 3
4	Ground Infrastructure Cost	Estimates cost to service provider to provide coverage to a geographically large sector.	Global Air Navigation Plan for CNS/ATM Systems – ICAO Doc 9750 (5.14) 11th ICAO Air Navigation Conference (Sept/Oct 2003) Recommendation 7/5 – Number 4

Suggested Institutional Criteria (2)

	Evaluation Criterion	Description (& sub-items)	Traceability
5	Cost to Aircraft	Estimates relative cost to upgrade avionics with new technology.	Global Air Navigation Plan for CNS/ATM Systems – ICAO Doc 9750 (5.14) 11th ICAO Air Navigation Conference (Sept/Oct 2003) Recommendation 7/5 – Number 4
6	Spectrum Protection	Gauges the likelihood of obtaining the proper allocation of the target spectrum.	Global Air Navigation Plan for CNS/ATM Systems – ICAO Doc 9750 (Statement of ICAO Policy on CNS/ATM Systems Implementation and Operation, Appendix A to Chapter 2, pg I-2-8)
7	Security – A&I	Assesses whether authentication and data integrity are provided	COCR Security Requirements (Table 4-11) Global Air Navigation Plan for CNS/ATM Systems – ICAO Doc 9750 (Statement of ICAO Policy on CNS/ATM Systems Implementation and Operation, Appendix A to Chapter 2, pg I-2-8)
8	Security – Robustness to Jamming	Assesses technology resistance to jamming.	COCR Security Requirements (Table 4-11)
9	Transition	Assesses acceptable transition characteristics, including: • return on partial investment • ease of technical migration (spectral, physical) • ease of operational migration (air and ground users)	Global Air Navigation Plan for CNS/ATM Systems – ICAO Doc 9750 (Statement of ICAO Policy on CNS/ATM Systems Implementation and Operation, Appendix A to Chapter 2, pg I-2-7)

Using Technology Evaluation Criteria

- Derived technology evaluation criteria were presented to the ICAO Aeronautical Communication Panel in March 2006
  - Comments have been received and addressed
- Metrics for evaluation criteria and an evaluation process are being developed
  - Technical performance metrics are being refined to reflect publication of COCR version 1.0
- Technology evaluations are in progress; results expected in June 2006